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Stress response in *Pectobacterium atrosepticum* SCRI1043 under starvation conditions: adaptive reactions at a low population density

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Abstract

The adaptive reactions of plant pathogenic bacterium *Pectobacterium atrosepticum* SCRI1043 under starvation conditions were studied. The main emphasis was given to the peculiarities of stress responses depending on the bacterial population densities. When bacteria were subjected to starvation at high population densities (10^7–10^9 CFU ml^{-1}), their adaptive reactions conformed to the conventional conception of bacterial adaptation related to autolysis of part of the population, specific modification of cell ultrastructure, activation of expression of stress responsive genes and acquiring cross protection against other stress factors. In contrast, at low initial population densities (10^3–10^5 CFU ml^{-1}), as described in our recent work, the cell density increased due to multiple cell division despite the absence of exogenous growth substrate. Here we present data that demonstrate that such unconventional behavior is part of a stress response, which provides increased stress tolerance while retaining virulence. Cell morphology and gene expression in high- and low-cell-density starving *Pba* cultures were compared. Our investigation demonstrates the existence of alternative adaptive strategies enabling pathogenic bacteria to cope with a variety of stress factors, including starvation, especially necessary when residing outside of their host.

Keywords: Cell division; Stringent response; ppGpp; RpoS; Cross-protection; Bacterial ultrastructure

1. Introduction

The life cycle of most microorganisms includes long non-growing periods under unfavorable conditions, such as starvation, non-optimal temperature, high osmolarity, etc. [31]. To adapt to non-permissive conditions, bacteria possess mechanisms for directed modifications of their metabolism and cell morphology [7,26].

Under stress conditions, bacteria induce the stringent response, which causes cells to divert resources away from growth and division in order to promote survival [13,32]. The main event at this time is bacterial growth arrest. The stringent response is mediated by alarmone guanosine 3′,5′-bisdiphosphate ((p)ppGpp) produced by synthetase RelA and/or synthetase/hydrolase SpoT. ppGpp binds to RNA polymerase leading to the cessation of transcription of ribosomal and transfer RNAs.

A crucial role in the adaptation process under stress conditions is played by sigma factor RpoS, which regulates the expression of genes related to stress resistance, cell morphology, metabolism, virulence and lysis [41,50]. RpoS is generally recognized as being in charge of cross-protective effects, when the influence of one stress factor renders cells more tolerant to a variety of stresses [48]. Additionally,

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